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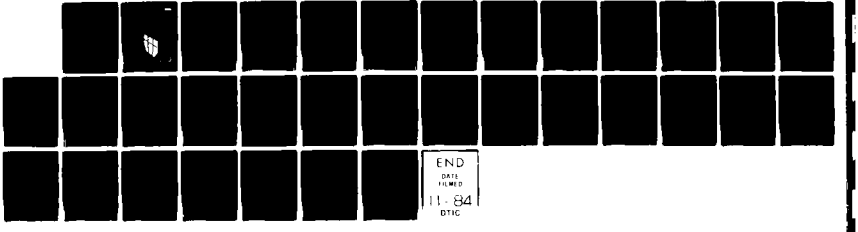

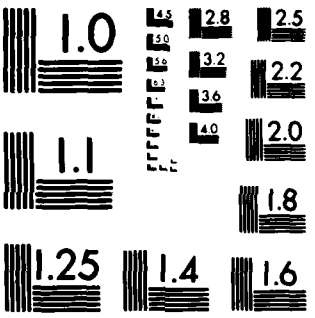

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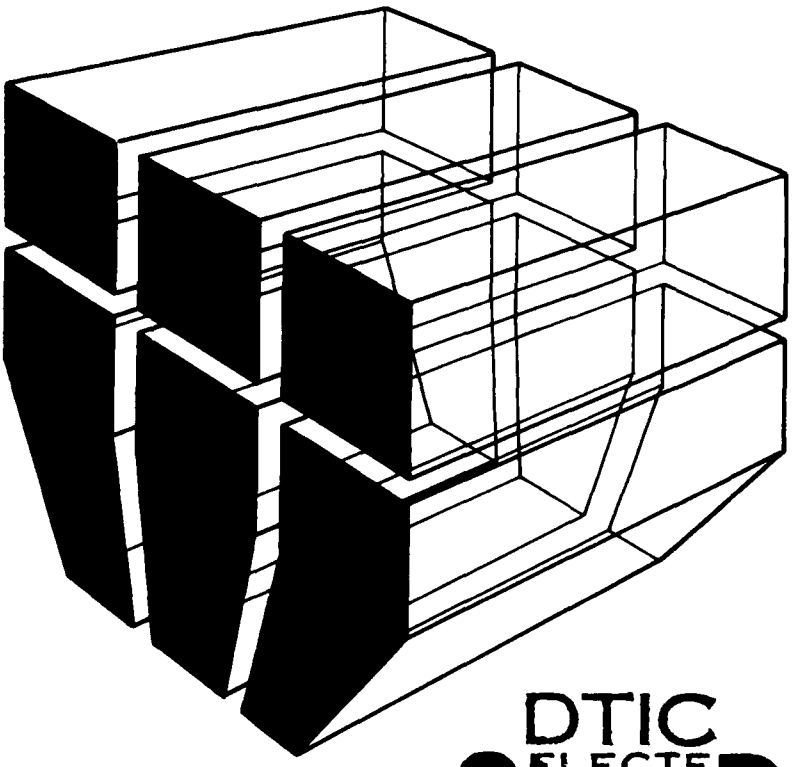
US Army Corps
of Engineers
Construction Engineering
Research Laboratory

CERL
Technical Report P-162
August 1984

Microprocessor Applications
to the MC Process

# ADP DOCUMENTATION AND SPECIFICATIONS FOR MICROCOMPUTER APPLICATIONS TO THE MILITARY CONSTRUCTION PROCESS (MICRO)

by
Carl E. DeLong





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This report documents the results of a prototype evaluation test (PET) of microcomputer applications in a Corps of Engineers construction field office and provides an economic analysis of the PET.

The PET was conducted in FY82 at a Corps field office at Wright-Patterson ~~Air Force~~ AFB, OH. ~~Base, Ohio.~~ It tested microcomputer applications to project management systems, data base management systems, word processing systems, and communications systems. Results of the PET showed that use of microcomputers is both successful and cost-

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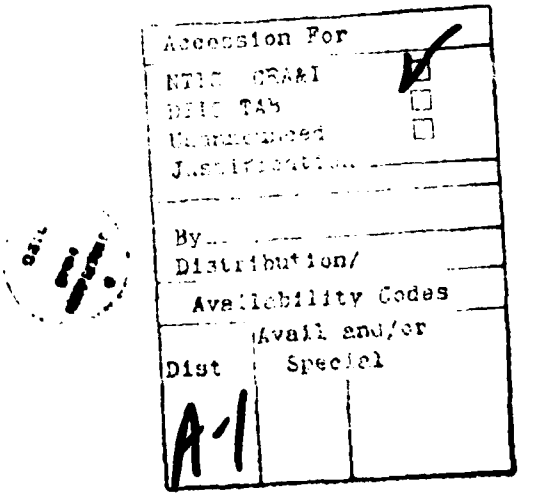
effective. The system saves time, requires less manpower, is user-friendly, and significantly enhances office operations. An economic analysis of the PET showed that microcomputers are relatively inexpensive to use and provide significant tangible and intangible benefits.

## FOREWORD

This project was performed for the Directorate of Engineering and Construction, Office of the Chief of Engineers (OCE), under Project 4A762731AT41, "Design and Construction of Fixed Military Facilities"; Task A, "Design and Construction"; Work Unit 35, "Microprocessor Applications to the MC Process." The applicable QCR is 303.006. The OCE Technical Monitor was Mr. Phil Pinol, DAEN-ECC-C.

The research was conducted at the U.S. Army Construction Engineering Research Laboratory (USA-CERL) by the Facilities Systems (FS) Division. Mr. Edward Lotz is Chief of USA-CERL-FS.

COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.



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## TABLES

# ADP DOCUMENTATION AND SPECIFICATIONS FOR MICROCOMPUTER APPLICATIONS TO THE MILITARY CONSTRUCTION PROCESS (MICRO)

## 1 INTRODUCTION

### Background

Having on-site microcomputer-based systems dedicated solely to the needs of the Corps of Engineers construction field office is a new idea. Such systems are needed because (1) previous computer systems designed primarily for higher-echelon users have not fully addressed the needs of the field office, and (2) the workload/personnel ratio has reached the level where better tools are essential to manage the workload successfully.

The feasibility of using computers in field offices has greatly improved during the past few years because of microcomputer technology advances and industry competition. This has also lowered their costs and made them more economical for the Corps to use.

In 1982, the Army conducted an in-process review (IPR) of a project being conducted to evaluate microcomputer applications to the military construction (MC) process (MICRO). The review included presentation of the results of a pilot test of MICRO at the Corps of Engineers construction field office at Wright-Patterson Air Force Base, Ohio. The reviewers decided that further pilot testing was not needed, but that there should be a Prototype Evaluation Test (PET) of the system. The reviewers also recommended further development of the project and fielding of the system as soon as possible.

Army Regulation (AR) 18-1[1] provides policy and guidance for selecting and implementing computer systems; part of this policy is the requirement for an Army Automation Economic Analysis. This economic analysis is reviewed by the Office of the Chief of Engineers before the system is implemented.

### Objective

The objective of this report is to transmit the results of MICRO testing and development through FY82 and to provide an economic analysis of microcomputer applications at a construction field office.

### Approach

A Prototype Evaluation Test Plan to provide guidance for the management and technical aspects of microcomputer applications was developed and distributed in January 1982. That plan defines, in general, the following sequence of activities:

1. Select a construction field office with appropriate workload and willingness to participate in the test.

2. Help the test site personnel define functional requirements.

3. Procure and install computer hardware and software capable of meeting the requirements.

4. Monitor the use of the computer system, evaluate the benefits derived, and modify the system to meet needs not originally identified.

5. Prepare system specifications based on test results.

6. Publish a guide to provide pertinent information to those planning the implementation of microcomputer systems in construction field offices.

The PET was conducted during late FY82, and performance specifications for the Project Management System (PMS) portion of the project were then written based on the PET results.

### Mode of Technology Transfer

The information in this report will be disseminated to Corps offices through an updated edition of U.S. Army Construction Engineering Research Laboratory (USA-CERL) Technical Report P-146, *Microcomputer Selection Guide for Construction Field Offices.*[2] It is recommended that the specifications provided in this report be used as examples for writing specifications for microcomputer systems. The specifications should be modified to individual installation needs and form the basis for procurement documents.

[1] *Army Automation Management,* Army Regulation 18-1 (Department of the Army, 15 August 1980).

[2] Glenn Colwell and Michael O'Connor, *Microcomputer Selection Guide for Construction Field Offices,* Technical Report P-146/ADA130245 (U.S. Army Construction Engineering Research Laboratory, 1983).

# 2 FIELD OFFICE DESCRIPTION AND CURRENT PROJECT MANAGEMENT PROCEDURES

The typical construction field office administers several million dollars of construction placement annually and performs or supports the performance of nearly every function in the Corps mission. The following are some of the functions performed in a construction field office to which microcomputers could be applied. The descriptions include an explanation of how these functions are currently performed. Each Corps District, based on its needs, defines operating procedures for carrying out these functions within the guidelines of Army and Corps of Engineers policies and regulations.

### Contract Administration

The field office is responsible for administering construction projects from start to finish. Network diagrams or bar charts are used in most offices to track performance and schedules and contract modifications. Documentation required includes progress reports, daily inspection and quality assurance, transfer of completed facilities and equipment documentation, contractor performance rating, and close-out reports.

The present procedure is to manually review and evaluate the contractor's network analysis system (NAS) submittal. The contractor's NAS is used to monitor job progress, identify delaying factors, evaluate the impact of changes, and for payment purposes. Progress reporting is usually based on output from the contractor's network. Detailed analysis is impossible without automated system support.

### Cost Accounting

Up-to-date records are required for available construction contingency funds, cumulative contractor earnings, employee time, requisitions, receiving of materials and services, travel, and government vehicle costs. Ledgers are now maintained manually, and computations are performed with hand-held calculators.

### Technical Functions

Included are review of shop drawings; preparation and processing of contract modifications; cost estimating; constructibility review with analysis of construction duration, and impact evaluation of contract modifications for time and/or cost. These functions are now performed manually and maintained on ledgers. Some data are unobtainable.

### Other Functions

Other functions and recordkeeping and reporting requirements fall into the areas of property accountability, safety, labor relations, physical security, personnel administration, correspondence, environmental protection, and overall office management.

Typing from rough written drafts is still the most common procedure. A few offices with small microcomputer systems have access to word processing programs, but are hampered by the lack of a letter-quality printer.

# 3 COMPUTER SUPPORT FOR CONSTRUCTION FIELD OFFICES

### Project Management System (PMS)

PMS software is available from many vendors at low cost. This system will operate on a variety of microcomputer units. Many of these PMS programs will provide the field office with the much-needed capability to quickly analyze the project schedule, perform "what if" exercises, and analyze the impact of change orders. The contract administration, cost accounting, and technical functions areas of a field office can benefit greatly from a PSM.

### Data Base Management Systems (DBMS)

DBMS software is also available from several vendors to operate on many types of microcomputers. DBMSs facilitate the gathering, storage, manipulation, and retrieval of information. Many field office functions could be performed more efficiently through application of a DBMS.

### Word Processing Systems

Word processing systems are replacing the traditional typewriters, because they are more flexible and cost-effective. Most Corps field offices have enough required paper production (correspondence, reports, forms, etc.) to justify a word processing system.

### Communication

Efficient and effective management requires rapid communication of information between the field office and its District office. Regular mail channels are too slow and unpredictable. Communications software allows microcomputers to exchange information electronically, in any form, almost instantly. This can be done automatically, without the need for personnel. For example, a common data base can be established through which AMPRS data, input by the field office,

can be accessed by the district via auto-dial/auto-answer modems; likewise the field office can access AMPRS reports using the same method.

## 4 WRIGHT-PATTERSON AREA OFFICE AUTOMATION

Louisville District's construction field office located at Wright-Patterson Air Force Base was selected as the test site for evaluating the benefits to be gained by office automation. An agreement was reached wherein USA-CERL would provide the equipment, and the field office would provide the operating personnel and maintain records of use.

Field office personnel, assisted by USA-CERL, examined their mission and procedures to determine where automation might most benefit them. Functional requirements were listed and prioritized. From this analysis, the greatest need was determined to be in the area of project scheduling and project status determination, so a project management system application was chosen. Corps personnel are currently at a serious disadvantage, because they are solely dependent on the contractor for updating progress schedules and do not have in-house ability to analyze the effect of changes on the schedule.

Hardware and software were selected, purchased, and installed to provide the field office with the ability to analyze the project schedule, rapidly update it as changes occurred, and evaluate the impact of change orders. Key personnel were given a few days of formal training on the new system, but the major training was acquired on the job.

Benefits to the Corps were significant. The manpower required to maintain the automated system was less than that needed with the manual procedures, and with the new system, more and better information was available to decision-makers.

The success of the project management system application showed that many other field office operations could benefit from automation. The system was therefore expanded to include: the ability for more than one person to use the system simultaneously; the ability to maintain information in areas such as submittals, modifications, vehicle maintenance, personnel, partial payments, correspondence, etc., and to retrieve this data in specific formats; the ability to prepare correspondence and forms; and the ability to transmit data electronically between the field office and District office.

As a result of the expanded requirements, the system hardware was upgraded and supplemented, and more software was obtained and installed. With these additions, the Wright-Patterson Area Office system had the full spectrum of office automation capability: a project management system, a data base management system, a word processing system, communications, and multi-user capability. Only a few days of training were required to start using the new systems, and all of the system programs were soon being used effectively.

During the PET, the test system was used intensively. Collected data showed a use rate averaging more than 8 hours per day. In many cases, the system was used overnight for network (PMS) calculations. However, the PMS was not used daily after the initial network had been input.

One of the two workstations was designated as a word processing station, but it would often be used for data base management input; this resulted in the secretary suggesting that the terminal be dedicated to word processing. The word processing capability allowed minor corrections to letters without retyping, which saved considerable effort.

The Wright-Patterson Area Office readily gave up old, long-established procedures when personnel learned that a microcomputer system could provide better results with the same amount of, and sometimes less, manpower. Besides allowing Corps personnel to do their jobs better, it allowed them to obtain information that there had not been time enough to get before. Because the computer system permitted the field office to monitor the project more closely, rapport with the contractor improved. The contractor was more inclined to accept the Corps position in negotiations because he knew that it was based on factual and timely information. Communications with the District improved because electronic transfer of information and reports assured timely receipt.

The Wright-Patterson test demonstrated conclusively that microcomputer systems can effectively support and enhance construction field office performance. The intensive use of data base applications for office operations demonstrates the need for this type of system for management of office functions. Applications such as project information files, future work files, and submittal registers proved useful during the

test, generating several reports helpful to management. The extensive use of the DBMS and word processing packages showed that these systems will provide immediate benefits to a field office. Transition from manually oriented procedures to a computer-based system requires a minimum of training and is not a serious obstacle, once the benefits are demonstrated.

With recent advances in microcomputer technology, the cost of implementing and maintaining an appropriate system is relatively inexpensive. Several conclusions can be drawn based on the test results.

1. Computer equipment can be installed and used effectively in construction field offices.

2. No increase in personnel is required.

3. Training is required to effectively use the equipment and software.

4. Data base applications and word processing will be used heavily immediately and will provide daily benefits; however, use of automation for impact analysis will take longer due to the extra effort required by the staff.

Appendix A provides the detailed economic analysis; Appendix B provides detailed cost/benefits calculations.

The type of software and hardware used in this test represents a generic class of system. The following chapter on specifications will allow the potential user wide latitude in selecting specific items from the numerous hardware and software available on the market that meet the broad standards established in this test.

# 5 SPECIFICATIONS

Field tests of microcomputer applications at Wright-Patterson Air Force Base Area Office enabled USA-CERL to develop the following list of recommended performance specifications based on actual field needs over a 2-year period.

### General Specifications

The following paragraphs are recommended as part of the general requirements for contractors supplying microcomputer systems.

Purpose: Describe how the microcomputer system will be used.

Evaluation: Clearly state how the bidder's proposal will be evaluated.

Installation, Testing, and Acceptance: Provide a schedule for each item.

Training: Detail the types of user training needed.

Maintenance: Discuss various acceptable options for hardware and software maintenance.

System Implementation: Discuss special features needed for system implementation, such as expandability.

Inspection and Acceptance: Clearly state inspection and acceptance procedures.

Benchmark Data: Provide benchmarking information for acceptance testing. The acceptance procedure should be completed within 2 weeks of contract award.

Operating Environment: Detail the conditions under which the system must perform, such as temperature, humidity, utility requirements, etc.

Materials and Supplies: Outline any additional materials required, such as ribbon and paper.

Deliveries and Installation: Provide delivery schedule and installation location.

Additives: Detail any additives, if they are considered.

### Hardware Specifications

The following specifications may be used for writing contracts for hardware.

The hardware for the basic system shall comply with the specifications listed below for a single user station. Components should be new (unused).

1. One (1) user station with CRT having selectable 132/80 character width by 24 lines, 9600 baud minimum transfer rate, and addressable cursor and full ASCII upper- and lower-case detachable keyboard (true descenders) with numeric keypad.

2. Central Processing Unit(s) (CPU) capable of supporting a multi-user operation (four minimum).

3. One (1) printer capable of at least 180 characters per second in data/draft printing mode and having 132-character carriage width and a tractor feed attachment in addition to standard friction form feed.

4. Mass data storage unit(s). The amount of on-line data storage provided shall be consistent with the software requirements, but shall include a minimum of 20 MBytes (unformatted) storage on hard disk, of which at least 10 MBytes must be on removable hard disk.

5. An AC powerline filter for conditioning of surges, noise, and interference.

6. All connectors and accessories needed to make a functional system. All cabling, connectors, and incidental items needed to render a fully operational system are required, including operating manuals.

Compactness of the system is required to allow transportation in one van, in a volume of about 6 ft by 4 ft by 4 ft.

The system shall support expansion to the following configuration: four (4) user stations, two (2) printers, mass data storage to include 20 MBytes (unformatted) minimum of hard disk, a serial port for communications, and one (1) modem (300/1200 baud minimum). The system shall be furnished with an adequate number of unoccupied ports to allow for this expansion.

**Software Specifications**

The following specifications may be used for writing contracts for software.

*Operating System Software*

The operating system shall support four or more users simultaneously. A large market base of software must be available for the offered operating system.

The operating system must be able to catalog, create, copy, rename, and delete files.

The system must be able to use hardware peripherals, such as terminals and printers, from at least one other vendor besides the equipment supplier (i.e., one each of another vendor's terminal and printer).

The system must be able to link precompiled routines.

The following must be available for later addition to the system:

1. A higher-level language compiler (ANSI FORTRAN), linker, loader and debugger, and compiler libraries (math, input/output, merge/sort).

2. A system editor (screen-oriented) and a system assembler and debugger.

The system must be documented. Users' manuals for software shall include all operations/commands and sample uses.

The system shall prevent short-term character buffering losses due to output to slower devices (e.g., printer) or during disk input/output, by means of a "read ahead" software function for all interactive terminals.

*Project Management System Software*

The system must be interactive and user-friendly, leading the operator through the steps of using it. Interactive help, prompts, and menus of commands must be provided. Users' manuals with documentation and descriptions of each command and its parameters as well as examples shall be provided.

The system shall complete the forward/backward pass calculations and other required data processing of a network of 1000 activities in less than two (2) hours.

The system must be able to output results to a file which can be reconfigured and the results transmitted to the CRT screen and/or to an output device, port, or file.

Overall features required are:

1. Interactive data entry and command processing.

2. Menu-driven inputs for commands.

3. Addressable cursor for screen-formatted inputs.

4. Input to the program, either onto a screen form or through lines of specific prompted information.

5. Error checking of syntax and semantics on input.

6. If the system requires user-defined network size limits, then the system must provide a procedure to salvage network data when size thresholds are reached

to avoid manual reentry of data into the larger-size network space.

The Project Management System must be able to perform at least the following functions:

1. Network Analysis: The system shall be based on a critical path type of network analysis, and shall accept data in both I, J notation and precedence notation. The precedence capability shall include leads and lags. The system shall be able to support the management of at least ten (10) concurrent projects, each with a maximum of 2000 activities.

2. Progress and Cost Reports: The system shall accept the current status of project activities (updating) and produce progress reports that compare the current status with the target schedule. The system shall also produce a partial payment estimate based on all completed work, including partially completed activities. Cost reporting will include budgeted and actual cash flow reports.

3. Network Comparisons: The system shall enable the user to analyze the impact of changes to a schedule by comparing a proposed schedule with an existing one. It shall produce a list of all activities that are affected by the proposed change as well as the information required for both schedules independently.

4. Super/Sub Networks (Fragnets or Hammocking): The system shall provide a means of processing subnetworks as part of a higher-level network with selectable fixed/variable dates on milestone (super-net) nodes.

5. Resource Reporting: The system shall provide the capability of assigning resources to activities and projects, and of tracking the resource use with appropriate reports. Automatic constrained resource scheduling and automatic resources leveling are *not* required.

6. Variable Calendar: The system shall accept 5-, 6-, or 7-day workweeks and be able to start a schedule on any calendar day. Variable holidays (up to ten [10] days), shutdowns, and Julian and Gregorian calendar dates shall be accommodated.

7. Loop Detection: Loop detection (multiple) is required.

8. Report Writer: The system shall include a report writer that allows flexibility in formatting and summarizing reports. Such reports shall be made possible by sorting and selecting relevant activity attributes such as activity number, character code, duration, float, status, cost, date, duration, etc.

9. Graphical Output: Barcharts and networks printed by the dot matrix printer are required in daily and summarized weekly form. Windowing (chronologically selected portions of the network) must be supported.

Table 1 lists required features of the Project Management System software.

*Data Base Management Software*

The system must conform to one of the following: TB 18-103[3] documentation requirements for a CODASYL-based system (Chapter 4, Data Base Management Systems); a relational data base format, as

**Table 1**
**Required Software Features**

| Feature | Minimal Requirement |
|---|---|
| A. Network Features | |
| 1. Activities/Project | 2000 |
| 2. Relationships/Activity | 50 |
| 3. Relationships/Network | 6000 |
| 4. Activity Number | 5 digits |
| 5. Activity Description | 20 characters |
| 6. Activity Sort/Select Code | 6 characters |
| B. Input Features | |
| 1. Input Format | Menu, screen forms |
| 2. Input Edit | Error detection |
| 3. Input Feasibility | Syntax and logical checks |
| 4. Open Ends Detection (listing of beginning/ ending activities) | Required |
| 5. Time Segments | Days, weeks, fractions |
| 6. Error Override | No |
| 7. Automatic File Maintenance | Required |
| C. Resourcing | |
| 1. Editing of Resources | Required |
| 2. Availability Profile | Summary lists |
| 3. Resource Expenditure/ Activity | Linear, lump |
| 4. Utilization/Resource Type | Summary list |
| 5. Utilization/Activity | Summary list |
| 6. Resources/Activity | 6 |
| 7. Resources/Network | 30 |

[3] *Software Design and Development*, Technical Bulletin 18-103 (Department of the Army, 3 January 1983).

described in C. J. Date, *An Introduction to Data Base System*, 2nd edition, Addison-Wesley, 1977; or a record data management system having data fields definition, screen input definition, and output report definition.

The system must be able to perform the data operations of addition, subtraction, multiplication, division, Julian and Gregorian calendar dates, less than, greater than, and equal to.

The data management system will be used to develop files to monitor various construction administration tasks. The following information will be maintained, including minimum numbers:

1. Contract modifications register (150 to 300 records per register)

2. Personnel files and listings (30 personnel per file)

3. Equipment schedule and use (20 items)

4. Time and attendance (30 personnel per form)

5. Submittal register (20 contracts, 500 to 1000 records per contract)

6. Payroll monitoring (20 contracts)

7. Field office budgeting (1 file per office)

8. Files management (15 files per contract)

9. Claims register (25 per register).

The contractor shall configure the data base system to produce all the example reports contained in the benchmark package. This is necessary due to the requirement of information exchange between the new and existing systems.

The following attributes are required for data base management software:

1. Provision for users to develop their own data bases, input programs, and reports.

2. Relational calculus format or data record management format.

3. User-friendliness, with interactive commands (control, data input, and report generation). On-line help must be available.

4. Screen layouts and command menus for inserting data.

5. Error checking of syntax and error processing.

6. Selectable formatted output for locating data and descriptions on output.

**Word Processing Software**

The following are requirements for word processing software:

1. The system must be compatible with the project management package. Reports from the PMS saved in file form must be able to be merged into word processing tables and text.

2. The system must be able to run concurrently with the PMS, either with concurrent processing or with the PMS in a background mode of operation.

3. The system must have character, word, and line movement; deletion and insertion and block movement; and in-line editing.

4. The system must have text formatting for: overstriking; superscripts; subscripts; single-, double-, and triple-spacing; underlining; tabs; headers; footers; paragraphing; tables; justification (right, left, upper, lower); and pagination.

5. The word processing system should be compatible with the project management package. It must use brief and simple user command codes, be able to handle upper/lower-case text, and have a text-formatting capability. There must be special controls to avoid undesired large deletions and change errors.

6. It must have capabilities to handle:

a. Entering, changing, moving, and deleting text.

b. Listing text and any part of text.

c. Providing margins (left, right, upper, lower), paragraphing, and pagination.

d. Generating multi-form letters with only address changes.

e. Providing headers/footers.

f. Merging text from other files.

g. Entering tables (column or row).

**Communications Software**

The following features must be provided for communications software:

1. Interactive file transmission and terminal emulation (full/half duplex, automatic dial-up, autoanswer, and interactive and batch file transmission).

2. Message processing with error checking to and from major timesharing services and to the following devices: printers, terminal, and disk files.

**Integration of Software**

The following is required for integration of the software subsystems:

1. The data base system must be able to generate ASCII-formatted files. It must also be able to accept ASCII-formatted files as input.

2. The PMS must be able to accept ASCII files as input.

3. The data base system must be able to create ASCII files so that the word processing and communication systems can accept and process the data base system files.

4. The word processor must be able to edit data base files without adding extra default padding or control characters.

# 6 CONCLUSIONS AND RECOMMENDATIONS

This report has presented the results of developing and testing the MICRO system through FY82 and provided an economic analysis of microcomputer applications at a Corps construction field office.

Testing showed that use of a microcomputer system in applications for project management systems, data base management systems, word processing systems, and communications can be successful and cost-effective. This type of automation saves personnel a great deal of time; requires less manpower; provides better, more timely information; and is user-friendly. Microcomputers can provide very effective support in Corps field offices and will significantly enhance office performance. As shown in the economic analysis (Appendix A), microcomputer use will also be relatively inexpensive.

After evaluation by the Office of the Assistant Chief of Engineers, it has been recommended that the Corps of Engineers introduce the needed electronic data processing equipment, software, and training for the PMS into Resident/Area Offices. The PET evaluation at the Wright-Patterson Area Office supports this recommendation. Operational testing has begun at six other Corps of Engineers field sites. These tests will provide experience and data to further evaluate Resident and Area Engineer needs for automation.

Rapid advances in microcomputer technology have made the use of less expensive, but highly capable, hardware and software a viable alternative to the current system. The PET has proved that the benefits of computer support at the construction field office are substantive. With the capabilities of available systems increasing rapidly and their costs decreasing, future cost/benefit analyses will show even more favorable results. Thus, the *Microcomputer Selection Guide*, which reflects industry technological advances, should be used for system selection for all future systems.

# APPENDIX A: ECONOMIC ANALYSIS

## A1 EXECUTIVE SUMMARY

**Approval Request**

The Office of the Assistant Chief of Engineers (USACE) Blue Ribbon Panel on Construction Quality staff evaluation recommended "that the CE proceed rapidly to introduce the needed electronic data processing equipment, software and training in resident offices and at the supporting district/division offices. The cost effectiveness of automation equipment appears amply demonstrated by the SWD (Southwest Division) and AOWP (Area Office Wright-Patterson) experience; . . ."

Based on the prototype evaluation test (PET) results, it is recommended that microcomputers be delivered to construction field offices. This economic analysis is part of the documentation required for authorization to proceed with deployment.

**Statement of Need**

The Corps needs more effective and efficient management of construction projects. This need is immediate, since the projected workload is expected to double or triple by 1985, with little increase in manpower.

With these expected workloads and manpower constraints, field offices will require more effective and efficient general data handling to execute contract administration, office administration, and contract management. Automated systems will provide a more effective means of managing this field office data.

**Current System**

Most field office operations are still handled manually. Project management systems rely on contractor input for values. Data base applications are either nonexistent, or they are being laboriously maintained by hand. Examples of manual operations are shop drawing registers and modification and claims registers. Correspondence is hand-drafted and typed. Often, several drafts of the same material are prepared due to slight changes or errors.

**Objectives**

MICRO will have a major impact on the construction field office's performance, providing more effective, efficient management of construction projects. Corps staffing is not expected to change when automation is introduced; however, the quantity and quality of management will increase.

**Assumptions and Constraints**

*Project Management System (PMS)*

Initial estimates were made for the time needed to update network progress and pay estimates and analyze contract modifications, and for general data handling based on the project management system.

*Data Base Management System (DBMS)*

Initially, it was assumed that general data handling would include the data base manager and a text editor. An early assumption was that text editing would not be as beneficial as modification analysis, but would be considered part of the data-handling capability.

*Training*

Each system (PMS, DBMS, and word processing [WP]) requires minimal training. Software designed to be "user-friendly" makes user training quicker and easier. However, the Project Management System, while easy to use, assumes the necessary background in project planning. Likewise, the Data Base Management System is easy to use, but requires 1 week of training.

**Alternatives**

The following alternatives were considered. The PET system was configured as alternative IV for multiuser use.

I. Current System: no automation.

II. Microcomputer consisting of 64K-byte processor, dual floppy and/or hard disk, printer, CRT terminal (standalone micro system).

III. Terminal (CRT) with modem (RS232) with an input/output port and a communications port.

IV. Complete system consisting of 64K-byte or greater processor and/or hard disks, high-speed and letter-quality printers, video display terminals (CRT), 1200-baud modem, input/output ports, and communication line.

**Benefits**

The automated critical path method (CPM) application reports provided more detailed progress information to identify major project delays and to determine corrective actions. The testing also showed control of the paperwork flow when contractor submittals were monitored using the Data Base Management System. Correspondence and flow of information to control projects was increased by use of the word processing system. In one case, facility construction time was shortened.

Before the prototype testing, project management CPM analysis was the primary focus. During the test, data base applications, such as submittal registers for shop drawings, modifications and claims registers, etc., and correspondence, saw daily use, whereas modification analysis was on an as-needed basis. Initial estimates did not adequately account for the potential savings from these applications.

The interactive Automated Military Progress Reporting System (AMPRS II) has been put on hold. However, the program provides several benefits to the field office. It is included in the analysis, since it, or a system similar to it, will probably be fielded in the future. Field testing of AMPRS II, as compared to batch operations, has shown a decrease in the error rate. The 1981 error rate of 13 percent will decrease to less than 3 percent. It will enable the field to meet the increased workload for upward reporting.

**Costs**

| Alternative | Costs | Benefits* |
|---|---|---|
| I. Current | $14,320,000 | None |
| II. Standalone Microcomputer | $2,798,600 | $3,618,000 |
| III. Terminal | $1,859,000 | $1,747,000 |
| IV. Complete System | $4,563,000 | $4,990,000 |

**Recommendations**

Based on the results of the PET, it is recommended that microcomputers be authorized and purchased for construction field office use.

## A2 STATEMENT OF NEED

With the expected workloads and manpower constraints USACE faces, more effective and efficient means of general data handling must be used to execute functions such as:

a. Contract Administration: Contract administration records are needed to monitor and inspect projects from inception to completion, using network diagrams and bar charts, S-curves, etc.; to track performance schedules; and to process contract modifications. Documentation is also required of progress reports, daily inspection and general inspection reports, transfer of completed facilities and equipment documentation, contractor performance rating, and close-out reports.

b. Cost Accounting: Cost accounting is needed to provide up-to-date records of available construction contingencies, cumulative contractor earnings, employee time, requisitions, receiving of materials and services, travel, and government vehicle costs.

c. Technical Functions: Technical functions require review of shop drawings, contract modifications cost estimating, constructibility review with analysis of construction duration, and impact of contract modifications for time and/or cost.

d. Other Functions: Other functions, such as recordkeeping and reporting requirements, are needed for property accountability, safety, labor relations, physical security, personnel administration, and environmental protection.

e. Word Processing/Text Editing Functions: Considerable correspondence is needed to administer construction contracts. Since each construction contract uses several contractors, there will be much correspondence of both a technical and nontechnical nature, which requires coordination.

*The value of some intangible benefits is not included, partly because of the difficulty in quantifying them in dollars, and also because the use of microcomputers in construction field offices is well justified without them. Adding the value of benefits such as: the availability of more accurate and timely information, the ability to make more informed decisions based on that information, and the improved effectiveness and efficiency of limited manpower resources would produce an even more favorable cost/benefit ratio.

## A3 CURRENT SYSTEM

The construction field office administers several million dollars of construction placement and participates in construction management, contract administration, and office administration.

**Project Management System**

The present procedure is to review and evaluate the contractor's network analysis system (NAS) when submitted. In many cases, the contractor's NAS is used on a monthly basis for payment purposes. After-the-fact progress reporting is usually based on output from the contractor's network.

**Data Base Management System**

When the MICRO project started, no data base management systems had been implemented in the field offices. Since then, the Southwest Division has implemented a filing system program called "Data Factory." There has been considerable development of the system in the Division's operational field elements.

At Wright-Patterson AFB, filing is currently done by hand, with no cross-referencing. Most offices maintain various registers, such as suspense items and various submittal registers, by hand. Each report must be prepared and researched from scratch. Most offices have several unofficial files of collected data used to generate reports. Considerable time is used to maintain these files and prepare the reports.

**Word Processing/Text Editing**

Some of the larger Corps field offices now have word processing capabilities. Although a valuable addition, word processing was not in general use at construction field offices during the testing period.

However, a few Districts, such as Baltimore, have encouraged their use when justified. Manual typing from rough, written drafts is still the most common procedure. A few offices with small microcomputer systems have access to word processing programs, but are hampered by the lack of a letter-quality printer. It is common for field offices to type the same letter several times due to minor errors and changes.

## A4 SCOPE

At least 100 offices probably have a workload range that can be automated. The data handling activities now performed manually are to be supplemented with a microcomputer system. The automated CPM analysis forms the basis for determining contract scheduling changes, time extensions, actual progress summaries, partial payments, and impacts of contract modifications. In addition to the CPM, an automated data base management system supports various local information-handling activities such as upward reporting, updating, retrieval, and summarizing of data. Text processing requirements for reporting and correspondence are handled by an automated text editing/word processing system.

### Goals and Objectives

MICRO will have a major impact on the construction field office's performance. The need for more effective and efficient management of construction projects is immediate, since the projected workload is expected to double or triple, with little increase in manpower. Corps staffing elements are not expected to change.

MICRO will be operated at all field offices having a supportable workload. The systems will vary among offices, depending on office size and workload, but will be within a standardized framework.

MICRO will interface with the future AMPRS II and District/Division Harris and/or Honeywell computers.

### Development Plan

*Authorization*

To manage the decision processes, the organizational elements having authority and responsibility in managing MICRO's life cycle must be identified. Under AR 18-1, systems are classified by their software and hardware acquisition, operation and maintenance costs, and size (large systems require higher levels of authorization). Development and installation of small systems can be authorized by the Major Command in which it is used.

The project "Microprocessor Applications to the MCA Process" serves the Corps field offices. It requires fewer than 15 staff years of effort from concept to installation. The equipment configuration at the field offices cannot be classified as Data Processing Installations (DPIs). ADP personnel are not required to run and maintain these systems. It is recommended that MICRO be classified as a CLASS IV system for the following reasons: (1) only a single DPI, if any, is needed to manage the field equipment; (2) the equipment produces only minor impacts on current ADP support in the Corps; and (3) the development and installation effort requires fewer than 15 staff years.

The proponent of the MICRO system is the Office of the Chief of Engineers, Directorate of Engineering and Construction. Since MICRO is classified as a Class IV system, it is this organization's responsibility to initiate each stage of the system life cycle. These stages include development, acquisition, extension, and operations/maintenance. The first three stages are sequential; each leads to a decision for initiating the following stage. The proponent has the authority to approve or disapprove at each of these steps.

*Investment Strategies*

AR 18-1 authorizes acquisition of general-purpose automatic data processing equipment (ADPE). Purchase of ADPE requires approval of the Assistant Secretary of the Army, except for Class IV systems costing less than $300,000 and for procurement of 10 or fewer systems. Other options include leasing and lease/purchase. Leasing requires approval by the Major Command OCE.

It is recommended that a purchase strategy be used for the following reasons:

1. The microcomputer industry is not well enough established to provide leasing like the traditional high-cost computer market. However, this may change in the near future, since larger organizations are starting to market microcomputers.

2. The procurement action of project management systems during FY82 by USA-CERL showed that PMS vendors were not willing to lease or lease/purchase. Submitted bids were either nonresponsive or excessive. Comments from these vendors indicated that they did not want to lease.

3. Dedicated field office units can be configured to meet the specialized needs of each office. Lease options would require a base standard.

## A5 ASSUMPTIONS AND CONSTRAINTS

**Project Management System**

Initial estimates were made for updating network progress and pay estimates, analyzing contract modifications, and general data handling based on the project management system.

Updating Network Progress and Pay Estimates–
Initial Estimate: 90 staff hours/month with 25 percent savings.

Analyzing Contract Modifications–
Initial Estimate: 90 staff hours/month with 15 percent savings.

Data Handling–
Initial concepts assumed that general data handling would include the data base manager and text editing. Another early assumption was that text editing would be used infrequently.
Initial Estimate: 40 staff hours/month with 25 percent savings.

**Word Processing/Text Editing (WP)**

The prototype evaluation testing showed an increased emphasis on data base management and text editing, which is reflected in benefits provided by the system.

**Intangible Requirements**

*Project Management System*

The following are PMS requirements:

1. MICRO must help to manage the construction process more effectively.

2. The automated CPM applications must provide more information to identify major project delays and to analyze corrective actions.

3. Facility delivery time must be shortened.

4. The automated CPM applications must provide the opportunity for comprehensive analysis of modifications, considering more alternative approaches and schedules. As a result, the cost and time impacts of change orders can be minimized.

5. The commands must be entered interactively with immediate checking for data validity.

6. MICRO must provide data in a more timely fashion, decrease turnaround time, and prepare status reports.

*Data Base Management System*

The DBMS must organize data for several application programs. The system needs the following characteristics:

1. Immediate checking for command syntax validity and error processing.

2. Screen layouts and command menus provided for data loading.

3. Interactively entered commands.

4. Formatting for printing with the word processing system.

*Word Processing/Text Editing*

The text editing system must have the following characteristics:

1. Brief and simple user command codes.

2. Special controls for avoiding large deletion and change errors.

3. Lower-case text handling.

4. Easy to learn and remember.

**Impacts**

*Equipment Impacts*

Each field site will procure new equipment. The minimum configuration will consist of a video terminal, a microcomputer, mass storage either as floppy disks or hard disks, and a printer. USA-CERL's procurement action in 1982 showed that vendors of project management packages were not willing to lease at realistic prices, which precluded lease and lease/purchase contracts. The field site will need an air-conditioned room. Several electrical outlets should also be provided for the printers and terminals.

*Software Impacts*

Software is procured for each system. Most vendors discount significantly based on the volume of the

purchase. The following systems are basic to the needs of the field office: a project management system, a data base management system, and a word processing system. A user group will disseminate Corps-developed data base applications. During 1982, new PMS packages and other low-cost application packages became available which can more effectively benefit the field office.

*Organizational Impacts*

The PET has shown that the automated equipment did not increase or decrease staffing. However, one staff member should become the system manager. Training and support required is minimal to use either the Project Management Package or the Data Base Management System. Using the PMS, a college-trained engineer can, within 1½ hours, complete a small sample problem and understand system input. Inspectors and clerical personnel have been taught to input data into a preformatted screen for both the PMS and DBMS systems, and sophisticated users have picked up the use of data base and word processing systems with minimal instruction. Most data base programs, such as submittal registers, are easy to use. However, training should be mandatory for development work with the DBMS. This will require a 3- to 5-day training session, while a 1- to 2-day session will be sufficient for learning the word processing system.

*Operational Impacts*

The programs use menuing and screen-formatted input to facilitate data entry and to select reports.

At first, engineers interact with the machine; however, as the office becomes accustomed to the machine, clerical personnel input the data. Input into the machine may seem onerous until a procedure is developed. Later, however, the small added burden of loading data is outweighed by the benefits of the extensive analysis it provides. The machine's ability to provide printed material, especially tables and charts, in addition to typed material, produces significant time savings for clerical and engineering personnel.

*Project Management System*

The PMS software provides for an almost unlimited variety of reports based on the ability to select from 25 attributes, and to sort on another 25 attributes by using three operators (less than, greater than, equal to). Network listings and charts are available based on any one of 25 report formats. Network comparisons are also available.

Inputting the contractor's network into the system takes between 1½ and 2 days, depending on the project size. A skilled typist can easily input activities in less than 30 seconds, but on the average, the complete time per activity, including corrections, updating, and revising, is 52 seconds. This time produces a fully functional network for analysis. In one case, a 537-activity network was input in less than 1 day. A complete 1100-activity network would take 2 days. While this time might seem excessive, the Wright-Patterson personnel found that the same amount of time would have been used to evaluate a contractor's schedule and study the project. It was not necessary to devote full effort to input since the contractor submits a preliminary schedule. Instead, the input effort was spread over a period of time. Another benefit was that personnel were finding logic errors and front-end loading which they had not been able to do in the past. Thus, at no increase in time, they had gained increased knowledge of their jobs. While it would be difficult to prove that the system improved project performance, three major projects were completed on or ahead of schedule, after accounting for strikes and weather delays.

*Data Base Management System*

By the end of the test, the DBMS was being used to generate daily reports. It was used not only for the construction projects, but also for the full operations of the Area Office. Reports were being generated for inspectors, project engineers, the area engineer, and the District Office. Typical uses included submittal registers, modification and claims registers, general contract information, and financial tracking. This feature was starting to become an integral part of the office routine; people were expecting updated reports and complaining when they were not immediately available. A new method of operation was evolving and was not completed by the end of the test. It was clear that it was saving time in generating reports, as well as providing information never available before (see case study 4, Section 7).

The DBMS allows users to configure any report or report format they wish to use. It also allows the user to default to a standard format, which allows reports to be obtained based on keywords.

*Word Processing/Text Editing*

Initially, it was thought that text editing would support only the engineers; however, the test showed that word processing was used nearly all the time. A second station was set up and a secretary assigned to the terminal. The only time it was not used for word

processing services was when the engineers were running an extra PMS or DBMS program, which required use of the terminal.

The word processing system has all the features required for generating correspondence, including mailing labels and a dictionary. Output is via a letter-quality printer.

A significant feature is that PMS and DBMS reports normally printed on a dot-matrix printer can be printed on a letter-quality printer or merged with word processing files to produce correspondence-quality letters along with reports. The Wright-Patterson engineers used this feature when replying to contractors; they would include data from the system for substantiation.

*Communications*

Only a partial communications capability was available during the PET. Some file transfers accompanied reports transmitted to the District Office. A dial-in capability added later has proved useful for providing reviewing personnel with current information.

*Maintenance*

Vendors will provide hardware and software maintenance. Several options are available, depending on the procurement technique. For example, the vendor for Wright-Patterson provides both types of maintenance, and the hardware manufacturer has a national service organization which provides different levels of hardware maintenance. Also, TRW and Sorbis are providing repair services for several types of computer and peripheral equipment.

## A6 ALTERNATIVES

Four alternative configurations have been analyzed for use at 100 field offices:

I. Current system: no automation.

II. Microcomputer consisting of 64K-byte processor, dual floppy and/or hard disk, printer, and CRT terminal (standalone micro system).

III. Dumb terminal (CRT) with modem (RS 232 standard) with an input/output port and a communications port.

IV. Complete system consisting of 64K-byte or more processor and/or hard disks, high-speed and letter-quality printers, video display terminals (CRT), 1200-baud modem, input/output ports, and communication line.

Table A1 shows processing tasks for the various alternatives. The four alternatives represent potential hardware configurations which provide different levels of automated functional capabilities for CPM analysis, interface to other computer systems, data base management, and word processing activities. ADP-related costs for these alternatives include expenses for software acquisition and/or development, hardware acquisition, computer time-sharing services acquisition, training, and hardware and software operations and maintenance. Functional benefits include time savings gained by using the applicable automated function versus the current manual method.

**Table A1**
**Processing Capabilities**

| Tasks | Alternative I: Current | Alternative II: Small System S.A. Micro | Alternative III: CRT | Alternative IV: PET System Complete System |
|---|---|---|---|---|
| Local CPM processing | Manual | X | | X |
| Local editing, file creation, printing | Manual | X | | X |
| Local word processing/data base | Manual | X | | X |
| Remote job processing (CPM, AMPRS) | Manual/Batch | | X | X |
| Timesharing (CPM, AMPRS, if available) | Manual/Batch | | X | |

# A7 BENEFITS AND COSTS

**Benefits**

The four case studies analyzed below, which were conducted during the PET, indicate the range of benefits, both tangible and intangible, to be derived from automating construction field offices.

*Case Study 1: CPM Project - Alter Foreign Technology Division Photo Laboratory*

**Action.** Corps of Engineers (CE) employees updated and analyzed a copy of the contractor's network to determine delays and conflicts which resulted from interferences in a mechanical area.

**Discussion.** The contractor was delayed because of time required by the Government to solve an interference problem. The contractor submitted a request for a 45-day extension. The Corps analyzed the CPM network and developed an independent projection based on actual events. The results showed that the contractor was entitled to an extra 7 days. The Government's position was supported with strong analytical data, and the contractor accepted the Corps position, after negotiation. The contractor then signed a modification for a 7-day extension.

**Result.** The CE Area Office was able to establish a strong negotiating position to resolve the contractor's delay claim.

*Case Study 2: CPM Project - Fuels and Lubrication Laboratory*

**Action.** Area Office employees analyzed a copy of the contractor's network, including resource needs, to determine alternate construction methods for effectively decreasing the impact of a strike. The logic of the network was reworked to reduce time and costs.

**Discussion.** The contractor submitted a request for a 90-day extension based on shortages of concrete forms caused by late delivery and a labor strike. The contractor's CPM network was used to evaluate available resources and alternative construction methods. The number of forms available for concrete placement was limited. However, an analysis produced a sequence of events that would allow the contractor to do the same amount of work using the available concrete forms in less time and at a reduced cost. It showed how the contractor could recoup the time of the strike, reduce the cost of the impact, and save money. The Government's ability to independently analyze the contractor's network was instrumental in determining the optimum solution. The completion time was critical to the using service.

Evaluation of the resources available for the construction provided the information needed to revise the network. The contractor implemented the Area Engineer's suggestions and logic change. A change order for a 60-day extension was issued and accepted.

**Result.** Alternative construction methods which were implemented mitigated the impacts of late equipment delivery and a labor strike.

*Case Study 3: Project Data - Alterations and Improvements to Composite Medical Facility, Wright-Patterson AFB*

**Action.** The contractor's original register for this project was input into a data base. Area Office employees updated and maintained a submittal register of 4200 items, based on the contractor's original submittal. The data base manager program was used to generate reports for pending resubmittals, status of submittals received for review, submittals past due from the contractor, and status of approvals of submittals for preparatory inspections. Other reports were generated to list critical items for management decisions.

**Discussion.** Government project inspectors and engineers now have daily and weekly reports detailing the status of various submittals. Status reports can be generated in a matter of minutes; for example, a typical report is a listing of all submittals required prior to installation and their status. Another typical report lists all submittals more than 30 days old that require Government approval. Delinquent actions, whether contractor or Government responsibility, are flagged in time to apply effective corrective action before the job is delayed.

**Result.** The Field Office can produce reports based on a computerized submittal register. The project engineers monitor and evaluate the status of submittals from a data base. Special-purpose reports are now generated for everyday working operations and thus prevent job delays.

*Case Study 4: Management Reports*

**Action.** The Corps Area Office produces a series of repetitive management reports on the status of projects: a weekly progress report, status of payments, active contract status report, and a general contract

information progress report. Additional status reports are produced as needed. Before field office automation, these reports were produced manually. Now data is stored and retrieved automatically in the necessary format.

**Discussion.** The Area Engineer and District personnel need up-to-date information to provide effective management. Since most of the reports have a basis of common information (project name, project number, etc.) with only two or three items changing, reports can be generated in only a few minutes to help evaluate project status using a data base program. In the past, copies of each report would be updated by an engineer and then retyped. Updating required the services of an engineer for 1 hour per week and two secretaries for 5½ hours per week. The procedure required 44 hours total for all reports.

With automation, the engineer can make the changes interactively during an editing session and later produce the reports. The reports are listed on either a dot-matrix printer or a letter-quality printer. Thus, instead of three people being required for several hours, now only one engineer is needed for 1 hour. Secretarial time has been cut from 5½ to 4 hours per week for typing the various reports. The total resulting time savings was 8 hours per week. This time was used for the increasing workload of another project.

During the PET, a report was prepared weekly for the CE District Chief of Construction. After installation of the dial-in capability this report could be retrieved by District personnel. It was often prepared only 1 hour before retrieval.

**Result.** Field Office employees now monitor and generate management reports from a computerized data base. Specialized status reports are also developed for everyday working operations.

**Costs**

*Quantifiable Factors*

The advantages of one alternative over another were reviewed in terms of quantitative costs and benefits. Appendix B provides detailed cost/benefit calculations. Table A2 summarizes costs (cumulative discounted) for the four alternatives.

The system life of each alternative is conservatively assumed to be 5 years. Each alternative fully or partly satisfies the system functional requirements. The major incurred cost differences derive from initial hardware acquisition (low for the dumb terminals, high for the microcomputer systems) and operational costs (time-sharing services and in-house staff support). The current manual system incurs costs for modification analysis. The automated system approaches incur costs of equipment, etc., but not costs of modifications. Table A2 shows the yearly costs for the four alternatives.

**Table A2**
**Summary Costs–100 Offices**

| Alternatives | Discounted Costs (10%) | Cumulative Benefits |
|---|---|---|
| I. Current | $14,320,000 | None |
| II. Standalone Micro | $2,798,600 | $3,618,000 |
| III. Terminal | $1,859,000 | $1,747,000 |
| IV. Complete System | $4,563,000 | $4,990,000 |

*Unquantifiable Factors*

The various alternatives have somewhat different operational characteristics. Thus, their evaluations require subjective review of other factors such as flexibility for growth, ease of use, ease of maintenance support, and capabilities for supporting project management activities, such as critical path method analysis, submittal registers, and correspondence. Table A3 compares the four alternatives in terms of these unquantifiable factors.

The objective of using the proposed automated tools is to manage the construction process more effectively. The automated CPM applications provided more detailed progress measures and more information to identify major project delays and to determine corrective actions. Testing of the data base management system also provided control of contractor submittals. Correspondence and flow of information to control projects was increased by the use of the word processing system. Indications are that use of the system shortened facility construction time.

The automated CPM applications provide comprehensive analysis of modifications by allowing consideration of more alternative approaches and schedules. Significant analysis and detail can now be provided for negotiation. As a result, more cost-effective and timely changes were possible during three test projects.

The resultant cost benefits to the final construction costs (i.e., costs of the facility) are difficult to document and validate without long-term studies of many projects. However, the introduction of automated CPM analysis of progress reporting and impact analysis

**Table A3**
**Ranking of Unquantifiable Factors**

| Alternative | Easy Use | Easy Maintenance Support | Flexibility for Growth | Proj. Mgmt. Support |
|---|---|---|---|---|
| I. Current | | | Low | Low |
| II. Standalone Micro | High | | High | High |
| III. Terminal | High | High | | Low |
| IV. Complete System | High | | High | High |

provides the potential for large savings in the construction costs. Presently, costs due to modifications (both direct and indirect impacts) in Corps military and civil works projects involve millions of dollars annually.

Before the prototype testing, project management CPM analysis was the primary focus. During the test, data base applications, such as submittal registers for shop drawings, modifications and claims, etc., and correspondence, saw daily use, whereas modification analysis was on an as-needed basis. Initial estimates did not adequately account for the potential savings from these applications.

## APPENDIX B: DETAILED COST/BENEFIT CALCULATIONS

### Background

The economic analysis was performed for the 100 field offices having a significant military construction workload within the continental United States. The workload analysis was performed for project data, field office staffing data, and project task data. The project data included averages for dollar value (CPM and non-CPM); percentage having CPM, average number of activities, and dollar value per activity. The field office staffing data included the average number of staff, the average dollar value of construction projects (military), and the average number of projects. Equipment costs are based on the cost of purchase. These figures were used to determine which alternative is most cost-effective. The results presented here reflect information gained during the PET.

### Alternatives

The following alternatives would support the field office staff in performing the tasks of monitoring, analyzing modifications, and general data handling for the project workload:

I. Current system

II. Standalone microcomputer

III. Terminal

IV. Complete system.

*Current System*

This system encompasses the current methods by which the field office staff manually process the monthly progress payments and reports, enter the AMPRS data, analyze the modifications, and process other data. The time and associated costs for performing these tasks is the baseline for comparing the other alternatives. No incurred costs for ADP-related activities are considered.

*Standalone Microcomputer*

With this alternative, field office staff use the microcomputer to help process monthly progress and payments, analyze modifications, and process other data. However, entry of AMPRS data continues to be manual. Incurred costs for ADP activities include hardware/software acquisition, training, and maintenance.

*Terminal*

For this alternative, field office staff use a terminal which is connected to time-sharing services to enter the AMPRS data, process monthly progress payments, analyze modifications, and process other data. Incurred costs for ADP-related activities include hardware/software acquisition, training, time-sharing services, and maintenance.

*Complete System*

Field office staff use the microcomputer system to process monthly progress and payments, analyze

modifications, process other data, and enter AMPRS transactions. Incurred costs for ADP activities include hardware/software acquisition, training, time-sharing services, and maintenance.

**Units and Unit Costs**

The component units forming the costs of the various alternatives are shown in Table B1.

**Alternative I—Current System**

1. Research and development costs: none.

2. Investment costs: none.

3. Operations and maintenance costs: none.

4. Functional costs: The manual methods provide no means for analyzing modifications of very large CPM networks.

The expected project cost of modifications is expected to be 10 percent of the 6 percent (now 3 percent) contingency. The average contract CPM is $8 million, and there is an average of 15 projects per office. An average of 10 percent of these are CPM projects. The modification analysis capabilities of MICRO give a savings of .06 X .10 X 8 million or $48,000 per project. 1.5 X 100 offices gives 150 CPM projects Corps-wide. The figures below assume that 75 new CPM projects begin each year and that the $48,000 savings is accrued during the first year of each project.

| | Value ($) | Discount ($) |
|---|---|---|
| FY3-7 (75 projects @ cost of 48K per project) | 3.6 million annually | 14.32 million* |

Discounted Cumulative 5 Years
*Discount factor: 3.977
Cost: $14,317,200
Benefits: None

**Alternative II—Standalone Microcomputer**

1. Research and development costs:

| | Value ($K) | Discount ($K) |
|---|---|---|
| Sunk Costs: | 336 | 336 |
| Total | | 336 |

2. Table B2 shows investment costs including software and hardware acquisition costs, initial training support, and documentation.

3. Operations and maintenance costs: These costs include system maintenance hardware and software, entering data into the computer, reviewing the data, and, if necessary, correcting erroneous data. The microcomputer is very much like a computer terminal. It does not require a computer operator; the engineer or clerk uses the computer directly. The software and hardware maintenance are recurring annual costs after the initial installation.

**Table B1**
**Component Units for Alternatives**

| Unit | Measure | Cost or Count |
|---|---|---|
| No. of Districts | CONUS MCA program | 37 |
| No. of field offices | CONUS MCA program | 100 |
| No. of staff | Per field office | 15 |
| No. of contracts | Per field office | 15 |
| Construction cost (CPM and non-CPM) | Per average contract | $1.3 million |
| No. of contractors | CPMs per office | 3 |
| No. of activities | Per contractor CPM | 900 |
| Construction costs | Per contractor CPM | $8 million |
| *Expected no. of in-house CPMs | Per office | 1 |
| No. of activities | Per in-house CPM | 500 |
| Construction costs | Per in-house CPM | $5 million |
| Construction duration | Months per CPM projects | 30 |
| Direct salary | Per field office staff | GS-11 ($26,142**) |

## Table B1 (Cont'd)

| Unit | Measure | Cost or Count |
|---|---|---|
| Direct salary | Construction div. staff | GS-11 ($26,142) |
| Indirect rate | All in-house labor | 100% |
| *AMPRS data prep. time and input to system @ 10 min. each | Per project/month (6 data elements) | 1 hour |
| *Progress and pay estimate data prep time | Per CPM project/month (60 activities @ 5 min. each) | 5 hours |
| *Modification analysis (review alternatives) | Per project/month (2 alts. @ 60 acts. @ 5 min. each) | 9 hours |
| *Other data handling (DBMS, WP) | Per project/month | 3 hours |
| Error rate | Batch AMPRS transactions | 13% |
| Error rate | Interactive syntax checking | <3% |
| CPM and DBMS trainer costs | Per visit (GS-11 @ 5 days @ 900 miles) | |
| nonvendor | $ 250 | |
| per diem | 450 | |
| transportation | 1050 | |
| labor + indirect | $1750 | |
| CPM and DBMS training costs (20/session-1 week) | Vendor training | $12,900 |
| AMPRS trainee costs (self-training) | Per field office (1 @ GS-11 @ 1 day) | $100 |
| WP trainee costs (1 @ GS-5 @ 2 days) | Per field office | $215 |
| Connect time for data entry at District | Per project per month per office | .5 hour |
| Additional connect time data at District | Per project per month per office | .25 hour |
| Other connect time (CPM, DBMS, etc.) | Per project per month per office | .5 hour |
| District office review Construction Division data | Per month per project (6 data elements, 5 min. each) | .5 hour |
| Interactive edit costs | Per office per year | $3,000*** |
| Word processing | Single user | $400 |
| Software acquisition | per office | |
| multi-user | $4,000 | |
| Data base management | Single user | $650 |
| Software acquisition | per office | |
| multi-user | $6,000 | |
| Project management | Single user | $2,500 |
| Software acquisition | Multi-user, large system | $20,000 |
| Software maintenance | Per office | $160 |
| Microprocessor hardware | Per office | |
| (processor–256K bytes, 20-megabyte–hard disk, printer, CRT) acquisition | Multi-user: 256K | $13,000 |
| | Single user: 64K | $8,000 |
| (System) vendor maint. | Monthly per office | $160 |
| CRT terminal acquisition | Per office | $1,000 |
| Terminal vendor maint. | Monthly per office | $25 |
| Modem (interface to micro) | Per office | $600 |
| Computer time-sharing services | Per connect hour (commercial) | $25 |
| | (CDC) | $8 |
| System life | No. of years in full operation | 5 |
| Discount rate | Per year | 10% |
| Sensitivity bounds | Expected value (upper and lower bounds) | ± 20% |

*Sensitive values.

**Value for GS-11 salary at step 3.

***6 months test data average from AMPRS testing.

**Table B2**
**Alternative II Investment Costs**

| | | | Value ($K) | Discount ($K) |
|---|---|---|---|---|
| FY1 or 2 | Training | PMS | 120 | 225 |
| | | Other | 105 | 225 |
| | Software Acquisition | Multi-user | 900 | |
| | | Single user | 245 | 1,145 |
| | Hardware Acquisition | Multi-user | 480 | |
| | | Single user | 560 | 1,040 |
| | Total | | 2,410 | 2,049* |

*Discount: .85 factor.

| | Value ($K) | Discount ($K) |
|---|---|---|
| Vendor Hardware | 104 | 413.6* |
| Maint. 100 offices | per year | |
| Total | 104 | 413.6 |

*Cumulative for 5 years
Discount: 3.977 factor

4. Functional costs: No functional costs are accrued.

5. Functional benefits: Functional benefits are accrued by using the microcomputer to help perform the monthly progress and pay estimates, analyze contract modifications, and perform general data handling. In this alternative, AMPRS transactions are filled out manually for batch submittal. The current error rate (13 percent) in the AMPRS transactions is expected to continue.

The typical field office handles 15 projects per year and is expected to process four contractor-submitted CPMs. For monthly updating, an average of 60 activities for each project must be processed by entering the actual completion percentage. These activities represent on-going activities (starting, in progress, finishing).

For the modifications analysis (typically one or more modifications per project per month), an engineer reviews two alternatives, each requiring review of the 60 on-going activities. With the automated analysis, the engineer will be able to evaluate the impacts on all (900) activities. Other general data-handling activities include data base management and word processing. Table B3 shows estimates of time savings.

During the PET, three contractor CPMs were used. A new CPM was being submitted when the PET ended.

**Table B3**
**Expected Time Savings per Office per Month**

| Project Activity | Project No. | Time (%) | Savings (hr) |
|---|---|---|---|
| Monthly update | 4 | 25 | 5 |
| *Modification analysis | 4 | 15 | 5 |
| **General data handling | 15 | 25 | 11 |
| ***Reports | 15 | 25 | 8 |
| Total | | | 29 |

*See case studies 1 and 2 of the economic analysis.
**See case study 3 of the economic analysis.
***See case study 4 of the economic analysis.

| | Functional Benefits | |
|---|---|---|
| | Value ($K) | Discount ($K) |
| 100 offices<br>29 hours per month,<br>for 12 months<br>12600 X $26.14/hr<br>34800 | 909.7<br>annually | 3,618* |

*Cumulative for 5 years
Discount: 3.977 factor

6. Total for Standalone Microcomputer:
Discounted cumulative 5 years:
Cost: $2,798,600
Benefits: $3,618,000

**Alternative III—Terminal**

1. Research and Development Costs:

| | Value ($K) | Discount ($K) |
|---|---|---|
| Sunk Costs | 336 | 0 |
| Total | 336 | |

2. Investment Costs: These costs include software and hardware acquisition costs, initial training (self), and documentation.

| | Value ($K) | Discount ($K) |
|---|---|---|
| CRT Acquisition | 100 | |
| Training AMPRS II | 84 | |
| Training (self) | 27 | |
| Total | 211 | 211 |

3. Operations and Maintenance Costs: These costs include recurring costs for time-sharing services and hardware maintenance. Additional support staff beyond the current AMPRS system staff should not be needed.

| | Value ($K) | Discount ($K) |
|---|---|---|
| Vendor hardware maint. | 30 | |
| AMPRS II user ID costs 3000 @ $100 | 300 | |
| Total per year | 330 | |
| Total Discounted | | 1,312.4* |

*Cumulative for 5 years
Discount: 3.977 factor

4. Functional Costs: No functional costs are accrued.

5. Functional Benefits: These benefits accrue when interactive time-sharing services are used to (a) check and edit the AMPRS transactions and (b) perform other general data handling (*i.e., simple editor*, Corps analysis programs, and a data base management system).

The capability to reduce errors will only be met at low transmission speeds because of line errors. Therefore, only low-speed lines are considered feasible for remote sites. Extensive use (more than several hundred activities) of CPM on a time-sharing system is not feasible because (a) the system is difficult to edit at these low transmission speeds and (b) the long batch printouts would have to be mailed, which is not acceptable for analyzing modifications in a short time frame.

The AMPRS interactive edit and check can reduce transaction errors from 13 percent to 3 percent.* The general data handling should achieve similar cost savings as in the micro-based version. Time savings and functional benefits are shown in Table B4 and Table B5.

6. Totals for Dumb Terminal:

Discounted Cumulative Years, 1 to 5:
Costs: $1,859,000
Benefits: $1,747,000

**Alternative IV: Complete System**

1. Research and Development Costs:

| | Value ($K) | Discount ($K) |
|---|---|---|
| Sunk Costs | 336 | 0 |
| Total | 336 | 0 |

2. Investment costs including software and hardware costs, *initial training* (both on-site and self), and documentation are shown in Table B6.

*Development of AMPRS II and related interactive systems has been postponed. Although they are not now operational, use of interactive systems will provide functional benefits in the future.

## Table B4
## Expected Time Savings (Per Office)

| Proj. Activity (Monthly) | No. of Proj. | Time Savings (%) | (Hours) |
|---|---|---|---|
| AMPRS Data Prep. (Office) | 15 + 2 errors | 10 | 2 |
| AMPRS Data Review (Dist.) | 15 + 2 errors | 10 | 1 |
| General Data Handling | 15 | 25 | 11 |
| Total | | | 14 |

## Table B5
## Functional Benefits

| | Value ($K) | Discount ($K) |
|---|---|---|
| 100 offices @ 14 hrs/mo, 16,800 hrs annually @ $26.14/hr | 439 | 1,747* |

*Cumulative for 5 years. Discount: 3.977 factor.

## Table B6
## Alternative IV Investment Costs

| | | | Value ($K) | Discount ($K) |
|---|---|---|---|---|
| FY0 | Hardware Acquisition | Multi-user | 240 | |
| | | Single user | 280 | |
| | | Subtotal | 520 | 520 |
| | Software Acquisition | Multi-user | 450 | |
| | | Single user | 123 | |
| | | Subtotal | 573 | 573 |
| | Training | PMS | 60 | |
| | | Other (DDMS, WP) | 52 | |
| | | AMPRS | 10 | |
| | | Self | 14 | |
| | | Subtotal | 136 | 136 |
| | | Total | 1,229 | 1,229 |
| FY1 | Hardware Acquisition | Multi-user | 240 | |
| | | Single user | 280 | |
| | | Subtotal | 520 | 496 |
| | Software Acquisition | Multi-user | 450 | |
| | | Single user | 123 | |
| | | Subtotal | 573 | 547 |
| | Training | PMS | 60 | |
| | | Other | 52 | |
| | | AMPRS | 42 | |
| | | Self | 14 | |
| | | Subtotal | 168 | 160 |
| | | Total | 1,261 | 1,203 |
| Discount: 954 | | | | |
| Total Investment Cost (FY0 and FY1) | | | | 1,232 |

3. Operations and Maintenance Costs: This case combines the alternatives of remote access to the AMPRS system and local intelligence for network analysis (CPM). The recurring costs, including in-house software maintenance and hardware maintenance coordination, time-sharing services for AMPRS transactions, and vendor hardware and software maintenance, are listed in Table B7.

4. Functional Costs: No functional costs are accrued.

5. Functional Benefits: In this alternative, benefits of both Alternatives II and IV accrue (the terminal and standalone microcomputer). This results in time savings of 24 hours per project per month. Table B8 gives estimates of time savings.

**Table B7**
**O&M Recurring Costs**

| | Value ($K) | Discount ($K) |
|---|---|---|
| AMPRS II user ID costs<br>Time-sharing<br>3000 x $100 | 300 | |
| Vendor hardware | 144 per year | |
| In-house admin. of maint. | 5 per year | |
| Total | 449 | 1,786* |

*Cumulative for 5 years.
Discount: 3.977 factor.

**Functional Benefits**

| | | Value ($K) | Discount ($K) |
|---|---|---|---|
| FY | 100 offices @ 40 hrs/mo, 48000 X 12 months = hrs annually @ $26.14/hrs | 1,254.7 | 4,990.0<br>902* |

*Cumulative for 5 years
Discount: 3.977 factor

6. Total for Complete System:

Discounted Cumulative Years:
Costs: $4,563,000
Benefits: $4,990,000

**Summary Costs—100 Offices**

| Alternatives | Costs | Benefits |
|---|---|---|
| I. Current | 14,320,000 | None |
| II. Standalone Micro | 2,798,600 | 3,618,000 |
| III. Terminal | 1,859,000 | 1,747,000 |
| IV. Complete System | 4,563,000 | 4,990,000 |

**Sensitivity**

The cost/benefit ratio shows a clear trend toward use of field office computers. Although several items are still cost-sensitive, they are not large factors in the analysis. Several intangible benefits have not been considered, because they are difficult to evaluate in terms of their dollar value. These include the availability of more information, an improved negotiating position with the contractor, and the benefits of having up-to-date, more accurate information. However, such an analysis would show an even more favorable cost/benefit ratio.

**Table B8**
**Expected Time Savings by Project (per Office)**

| Proj. Activity | No. of Proj. | Time (%) | Savings (Hours) |
|---|---|---|---|
| Monthly Update | 4 | 25 | 5 |
| Modification Analysis | 4 | 15 | 5 |
| General Data Handling | 15 | 25 | 11 |
| Word Processing | 15 | 25 | 8 |
| AMPRS Data Prep. (office) | 15 + 2 errors | 10 | 2 |
| AMPRS Data Review (Dist.) | 15 + 2 errors | 10 | 1 |
| Report Preparation | 15 | | 8 |
| Total | | | 40 |

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